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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

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Appellant(s): O. YOKOMIZO, et al

Serial No.: 08/470,424

Filed: June 6, 1995

For: FUEL ASSEMBLY AND NUCLEAR REACTOR

Group: 3641

Examiner: H. Behrend

APPEAL BRIEF

Commissioner for Patents
Washington, D.C. 20231

October 26, 2001

Sir:

This Appeal Brief is submitted on behalf of appellants in response to the final Office Action dated February 26, 2001, a Notice of Appeal having been filed on July 26, 2001. It is noted that a Petition to Withdraw Erroneous Holding of Abandonment accompanies this Appeal Brief as well as an Amendment to correct the dependency of claim 29.

(1) REAL PARTY IN INTEREST

The real party in interest is the assignee of this application, Hitachi, Ltd. of Japan.

(2) RELATED APPEALS AND INTERFERENCES

This application is a continuation application of application Serial No. 07/974,834, which is a continuation of

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earlier filed applications and an appeal was conducted in parent application Serial No. 07/974,834 under Appeal No. 1996-3167 in which a decision reversing the rejection of all claims under consideration was mailed February 8, 2000, such application now being issued as U.S. Patent No. 6,278,757. Appellants submit that the parent application and the decision by the Board in such application should have a bearing on the Board's decision in the pending appeal, in that while the claims of the parent application were directed to a fuel assembly and a nuclear reactor, the claims on appeal in this application relate to the method of operating the nuclear reactor utilizing the structure of the pending application, which disclosure is commensurate with the disclosure of the parent application.

(3) STATUS OF CLAIMS

Claims 24, 26, 29, 40-43, 50 and 52-63 are on appeal. Claims 1-23, 25, 27, 28, 30-39, 44-49 and 51 have been canceled. A copy of the claims on appeal, as amended by the Amendment submitted herewith, appear in the Appendix of this Appeal Brief.

(4) STATUS OF AMENDMENTS

An Amendment accompanies this Appeal Brief to correct the dependency of claim 29 which inadvertently depends from canceled claim 28 and has been amended to depend from claim

26. Since the amendment corrects an informality, it is assumed that the Amendment will be entered.

(5) SUMMARY OF INVENTION

The present invention is directed to a method of operating a nuclear reactor having a particular type of fuel assembly which includes a plurality of fuel rods and at least one water rod so as to reduce consumption of nuclear fuel substances.

Fig. 4 of the drawings of this application is a vertical sectional view of a fuel assembly in accordance with the present invention with a cross sectional view of the fuel assembly being illustrated in Fig. 6. As shown in Fig. 4 and as described at page 10, line 29, to page 13, line 22, the fuel assembly includes an upper tie plate 12, a lower tie plate 13 and a plurality of fuel rods 11 having a lower end portion held by a fuel rod holding portion 14 of the lower tie plate 13. A water rod 19 is disposed among the fuel rods and is held by the fuel rod holding portion of the lower tie plate. Several fuel spacers 16 are arranged in the axial direction of the fuel assembly 10 to maintain an appropriate distance among the fuel rods 11 which fuel spacers are also held by the water rod 19. The fuel rods are provided with fuel therein so that an average enrichment in an upper portion of the fuel assembly is greater than an average enrichment of a lower portion of the fuel assembly.

As more clearly illustrated in Figs. 7A and 7B of the drawings of this application and as described an page 13, line 23, to page 14, line 31, the water rod 19 consists of an inner tube 20, an outer tube 21 and a spacer 22. The outer tube 21 and the inner tube 20 are arranged concentrically with respect to each other with the outer tube 21 surrounding the outer periphery of the inner tube 20. The upper end of the upper tube 21 is sealed with a covering portion 23 and the upper end of the covering portion 23 is held by the upper tie 12 by being inserted therein. The covering portion 23 covers the upper end of the inner tube 20 so as to form a gap with respect to the upper end of the inner tube 20 and spacers 22 extend between the inner tube and the outer tube as more clearly illustrated in Fig. 7B. The lower end of the outer tube 21 is sealed with a sealing portion 24 and the lower end of the inner tube 20 penetrates through the sealing portion 24 to protrude downwardly while penetrating through the lower fuel rod supporting portion 14 of the lower tie plate 13. A coolant inlet port 28 is formed in the lower end of the inner tube 20 and is open in the space 15 of the lower tie plate 13 as illustrated in Fig. 4.

The water rod 19 as shown in Fig. 7A has a first coolant passage formed therein and the interior of the inner tube 20 forms a coolant ascending path 25. Further, an annular path formed between the inner tube 20 and the outer tube 21 defines a coolant descending path 26 which coolant descending path 26

communicates with the coolant ascending path 25 at the top portion 27 of the first coolant passage so that all of the coolant supplied into the cooling descending path 25 is introduced into the coolant descending path 26 in a downward direction opposite to the direction of the flow of coolant in the coolant ascending path 25. As is apparent, the coolant ascending path 25 has a coolant inlet port 28 while the coolant descending path 26 has at least one coolant delivery port 29 which are open in a region over the fuel rod supporting portion 14 as clearly illustrated in Fig. 7A of the drawings. The coolant delivery port 29 is arranged at a position higher than the fuel rod holding portion 14 and lower than the top portion 27 of the first coolant passage.

As described at page 14, line 32, to page 15, line 28, when the fuel assembly is loaded in a reactor core of a boiling-water reactor, most of the cooling water is directly introduced into the space 80 among the fuel rods 11 of the fuel assembly 10 passing through space 15 of the lower tie plate 13 and penetration holes 18 formed in the fuel rod supporting portion 14 as illustrated in Fig. 7A. The remainder of the cooling water that flows into space 15 of the lower tie plate 13 flows through the coolant inlet port 28 into the coolant descending path 25 of the water rod 19 and is delivered into the space 80 over the fuel rod supporting portion 14 to the inverting portion 27, the coolant descending path 26 and the coolant delivery ports 29. Thus, the space 80

represents a second coolant passage formed outside of the water rod 19 and being provided among the fuel rods 11 and between the at least one water rod and the fuel rods, between the upper type plate 12 and the fuel rod holding portion 14. As previously described, the fuel rod holding portion 14 has a plurality of penetration holes forming coolant passages for introducing coolant into the coolant passage 80 from a region lower than the fuel rod holding portion, i.e., the space 15, and as clearly illustrated in Fig. 7A, each of the coolant passages 18 have a cross-sectional area smaller than a cross-sectional area of the coolant passage 18 at least in an area of the coolant passage 80 which is immediately above the fuel rod holding portion 14.

The principle of operation of the present invention is described at page 9, line 1 to page 12, line 23, with respect to Figs. 1-3A-3C of the drawings of this application wherein Fig. 1 represents the schematic arrangement of the water rod 19 as illustrated in Fig. 7A as held in the fuel rod holding portion. In order to show the correspondence of the structure of Fig. 1 with that illustrated in Fig. 7A, the reference numerals utilized in Fig. 7A will be shown in parenthesis with those of Fig. 1. As shown in Fig. 1, the fuel assembly is provided with a water rod 1(19) which has a coolant ascending path 2(25) of which a coolant inlet portion 4(28) is open in a region lower than a resistance member (such as a tie plate) 6(14) provided at a lower portion of the fuel assembly and

which water rod has a coolant ascending path 3(26) that downwardly guides coolant from the coolant ascending path and which has a coolant delivery port 5(29) open in a region higher than the resistance member 6(14). The resistance member 6(14) has a plurality of coolant passage ports 7(18). The pressure differential ΔP changes between the region (15) lower than the resistance member 6(14) and a region (80) higher than the resistance member 6 depending upon the change in the flow rate of the coolant that flows through the coolant passage ports 7(18) formed in the resistance member 6(14). The pressure differential caused by vena contracta and increase of resistance varies nearly in proportion to the square power of the flow rate of the cooling water. Therefore, if the flow rate of the cooling water passing through the resistance body 6(14) changes from 80% to 120%, the pressure differential ΔP increases by about 2.25 times.

Fig. 2 illustrates a relationship between the flow rate of cooling water and the water rod 1(19) and the pressure differential between inlet and the outlet of the water rod 1(19) (pressure differential between coolant inlet port 4(28) and the coolant delivery port 5(29)). As described at page 9, line 26, to page 11, line 33, if the flow rate of the cooling water is increased starting from zero, the pressure differential between the outlet and the inlet of the water rod (19) once reaches a maximum value. As the flow rate of the cooling water is further increased, the pressure differential

between the outlet and the inlet of the water rod once drops to a minimum value and then increases monotonously due to the phenomenon shown in Figs. 3A to 3C.

Fig. 3A shows the condition in water rod at point S in Fig. 2 while Fig. 3B shows the condition in the water rod at a point T in Fig. 2 and Fig. 3C shows the condition of the water rod at a point U in Fig. 2. When the flow rate of the cooling water flowing through the water rod is very small (condition at point S in Fig. 2) the cooling water in the water generates the heat and evaporates being irradiated with neutrons and the like. The upper portion of the coolant ascending path 2(25) which is coupled to the upper portion of the coolant descending path 3(26) are then filled with vapor as shown in Fig. 3A. A liquid level L_1 is established in the coolant ascending path 2(25) and the pressure differential between the outlet and the inlet of the water rod is generated by the difference in the static water head between the liquid level L_1 and the liquid level L_2 of the coolant delivery port 5(29) outlet of the coolant descending path 3(26) of the water rod. The flow rate of the cooling water that flows into the coolant ascending path 2(25) maintains a balance with respect to the flow rate by which the vapor flows out through the coolant delivery port 5(29). As the flow rate of the coolant water is further increased from the point S in Fig. 2, the cooling water flows into the coolant ascending path 2(25) at a rate that is greater than the amount by which the cooling water is

vaporized. In such a case, (e.g., at the point T in Fig. 2), the cooling water flows down through the coolant descending path 3(26) as shown in Fig. 3B. At this moment, the static head in the coolant ascending path 2(25) is partly canceled by the weight of the cooling water that flows through the coolant descending path 3(26) and the pressure differential between the outlet and the inlet of the water rod becomes smaller than the maximum value S_0. As the flow rate of the cooling water further increases, however, the unsaturated water introduced through the coolant inlet port 4(28) is not boiled in the coolant ascending path 2(25) and the coolant descending path 3(26) (void fraction is very reduced), and is permitted to flow out through the coolant delivery port 5(29) (condition of point U in Fig. 2, Fig. 3C. Therefore, the water flows through the coolant ascending path 2(25) and the coolant descending path 3(26) almost in the form of a single phase stream as shown in Fig. 3C.

Under the condition of Fig. 3A, therefore, the static water head at the level of the coolant ascending path 2(25) and the level of the coolant delivery port 5(29) in the coolant descending path 3(26) are canceled by each other, so that the difference in the static water head becomes very small. However, since the cooling water flows at a large rate in the water rod, the pressure loss increase is due to friction and inversion in the flow of the cooling water and the pressure differential increases again between the outlet

and the inlet of the water rod. Owing to the above-mentioned phenomenon, the flow rate of the cooling water in the water rod varies greatly and the void fraction varies greatly, even though the pressure differential varies little between the outlet port and the inlet port of the water rod. Therefore, the void fraction can be changed greatly by changing the flow rate of the cooling water (flow rate in the reactor core) that flows in the fuel assembly, if the resistance of the resistance member 6(14) is so adjusted that the pressure differential between outlet and the inlet of the water rod is smaller than a pressure differential between the outlet and the inlet of the water rod which corresponds to the minimum value T_0 of Fig. 2 when the flow rate in the reactor core is 80% and that the pressure differential between the outlet and the inlet of the water rod is in excess of a pressure differential between the outlet and the inlet of the water rod that corresponds to the maximum value S_0 of Fig. 2 when the flow rate in the reactor core is 120%.

Reference is made to Fig. 33 and pages 41 and 42 of the specification, which describes the feature that the recirculation conduit 69 is provided with a recirculation pump 70 and that the output of a high level of the nuclear reactor can be controlled by changing the number of revolutions of the recirculation pump 70 and by increasing or decreasing the flow rate in the reactor core. More particularly, as described at page 42, lines 8-25 of the specification of this application,

the operation for shifting the flow condition in the water rod 19 from the condition of Fig. 3A to the condition of Fig. 3C, is achieved by increasing the flow rate in the reactor core, i.e. by increasing the number of revolutions of the recirculation pump 70. With the recirculation pump running at a speed that produces the flow rate of smaller than 100% in the reactor core, the condition of Fig. 3A is established in the water rod 19, whereby the vapor is built up in the coolant descending path 26. With the recirculation pump running at a speed that produces the flow rate of greater than 110% in the reactor core, the condition of Fig. 3C is established in the water rod 19, and no vapor is built up. The recirculation pump 70 serves to control the accumulating amounts of voids (vapor) in the water rod 19.

Page 15, line 33 to page 16, line 3 of the specification of this application provides that "This operation method applies for one fuel cycle (operation period of a nuclear reactor from when the fuel in the reactor core is replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing the fuel, i.e., usually, one year)." The definition concerning one fuel cycle is a matter of common knowledge to one skilled in art of nuclear reactors and reference is made to US Patent No. 4,285,769 which is cited in the specification of the present application at page 19, line 29, for example, and which corresponds to Japanese Patent Publication No. 44237/1983 also

disclosed in the specification of this application. US Patent No. 4,285,769, which issued in 1981, discloses in column 1, lines 37-43 that "Nuclear reactors are typically refueled periodically with an excess of reactivity sufficient to maintain operation throughout an operating cycle often in the order of one year in length of time. The reactor is then shut down and a fraction of fuel assemblies typically about one-quarter of the fuel assembly are re-placed." Column 5, lines 35 and 36 of this patent describes that "Fuel resides in the core for n cycles of operation of the core (where n typically is 4). Column 8, lines 59-65 of the patent provides:

> A reactor of the type described is refueled periodically with a partial batch of fuel which comprises some part of the core. Typically the reactor is operated for 12 to 18 months between refuelings, depending on the fuel enrichment, refueling batch size and utility grid requirements. These intervals of operation between refuelings are called "fuel cycles" or "cycle of operation".

US Patent No. 4,285,769 in column 13, lines 21-22, provides that "At the end of operating cycle the reactor is shut down for refueling." and Fig. 6A illustrates an example configuration of a refueled core for a fourth cycle of operation. Thus, US Patent No. 4,285,769 disclose that part of the fuel assemblies in the nuclear reactor are renewed once each fuel cycle, and renewed fuel assemblies stay in the nuclear reactor during four fuel cycles.

Page 18, line 33 to page 19, line 1 of the specification of this application, discloses "The fuel assembly 1 experiences the fuel cycle operation four times in the reactor core. Therefore, the conditions of Figs.3A, 3B and 3C are alternately repeated four times each." It is apparent that in an embodiment of the present invention, the fuel assembly stays in the nuclear reactor during four fuel cycles (e.g, four years).

As described at page 25, line 26 to page 26, line 28 of the specification, in accordance with an embodiment, the condition of Fig. 3A is established in the water rod 19 when the flow rate in the reactor core is smaller than 80% and that the condition of Fig. 3C is established in the water rod 20 when the flow rate in the reactor core is 110% with Fig. 17(b) showing the percentage flow rate in the core for respective fuel cycles. As described, the flow rate of 80% in the reactor core is the one which corresponds to the maximum value S_0 of Fig. 2 at which the cooling water is supplied into the water rod 19, and the flow rate of 110% in the reactor core is the one which corresponds to the point R of Fig. 2 at which the cooling water is supplied into the water rod 19. As described at page 26, lines 4-28 of the specification, during the period of up to 70% of both the first fuel cycle and the second fuel cycle, the flow rate is maintained at 80% as shown in Fig. 17(b) and the change in the output of the nuclear reactor due to the consumption of the core material is

compensated by gradually pulling out the control rods. From 70% of the fuel cycle to the end of the fuel cycle, the flow rate in the reactor core is gradually increased from 80% to 120% while halting the operation of the control rods. With the output of the nuclear reactor being controlled as described above, the surplus reactivity in this embodiment is maintained at a minimum level necessary for criticality for a predetermined period of time (Fig. 17(b)) at the end of each of the fuel cycles. Furthermore, Fig. 17(b) shows the increase of surplus (excess) reactivity at the beginning of the second fuel cycle and the third fuel cycle. In this manner, the present invention provides that the coolant surface formed in the water rod is raised by increasing the flow rate of the coolant during one period from a beginning of one fuel cycle and that the water rod is completely filled with the coolant during another period after the one period to the end of the one fuel cycle.

(6) ISSUES

I Rejections under 35 U.S.C. §112

(A) In the final Office Action dated February 26, 2001, the Examiner has rejected claims 24, 26, 29, 40-43, 50, 52, 53, 56-59 and 61-63 under 35 U.S.C. §112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time

the invention was filed, had possession of the claimed invention. The Examiner contends that there is no support in the original disclosure for particular claimed features of the aforementioned claims. More particularly, the Examiner indicates:

> Note that the above referred to limitations in applicants claims incorrectly indicate that the "renewing" takes place while the fuel assembly is in the nuclear reactor.

Irrespective of the fact that the claims do not recite the feature of "while" as contended by the Examiner, an issue on appeal is whether the recited features of the aforementioned claims find adequate support in the specification in the sense of 35 U.S.C. §112, first paragraph.

(B) The Examiner in the final Office Action has also rejected claims 24, 26, 29, 40-43, 50, 52, 53, 56-59 and 61-63 under 35 U.S.C. §112, second paragraph, indicating that the "claims are vague, indefinite, incomplete, misdescriptive and inaccurate in indicating that the renewing of the fuel assembly takes place while the fuel assembly is still in the nuclear reactor". Irrespective of the fact that the language of "while" does not appear in the claims and the Examiner has mischaracterized the claimed invention, another issue on appeal is whether the claims are in compliance with 35 U.S.C. §112, second paragraph.

II Rejections under 35 U.S.C. §103

(A) In the final Office Action, the Examiner rejects claims 24, 50 and 61 under 35 U.S.C. §103(a) as being unpatentable over Japan 61256282 in view of Sofer (US 3,910,818), such that another issue on appeal is whether the claimed features of claims 24, 50 and 61 are rendered obvious in the sense of 35 U.S.C. §103 based upon the aforementioned cited art taken in combination.

(B) The Examiner has also rejected claims 24, 50 and 61 under 35 U.S.C. §103(a) as being unpatentable over either Japan 0220686 or Japan 0031090 in view of Sofer alone or with Japan 61256282, such that another issue on appeal is whether the recited features of the aforementioned claims are rendered obvious in the sense of 35 U.S.C. §103 from the aforementioned proposed combination of references.

(C) In the final Office Action, the Examiner rejected claims 24, 26, 29, 40-43, 50 and 52-63 under 35 U.S.C. §103(a) as being unpatentable over Matzner (US 5,251,246) in view of Sofer taken with Japan 61256282, such that a further issue on appeal is whether the recited features of the aforementioned claims are rendered obvious in the sense of 35 U.S.C. §103 from the aforementioned combination of references.

(D) Additionally, the Examiner has rejected claims 24, 26, 29, 40-43, 50 and 52-63 under 35 U.S.C. §103(a) as being unpatentable over Matzner in view of Sofer and any of Japan 0220686, Japan 0031090 or Japan 61256282 further in view of

applicants own admission of prior art in the specification (e.g., see page 25). Thus, another issue on appeal is whether the recited features of the aforementioned claims are rendered obvious in the sense of 35 U.S.C. §103 from the combined teachings of the aforementioned art.

(E) Further, the Examiner has rejected claims 24, 26, 29, 40-43, 50 and 52-63 under 35 U.S.C. §103(a) as being unpatentable over Japan 61256282 in view of Sofer and further in view of Matzner or Kumpf (US 3,528,885), such that another issue on appeal is whether the recited features of the aforementioned claims are rendered obvious in the sense of 35 U.S.C. §104 from the combined teachings of the aforementioned art.

(F) The Examiner has also rejected claims 24, 26, 29, 40-43, 50 and 52-63 under 35 U.S.C. §103(a) as being unpatentable over either Japan 0220686 of Japan 0031090 in view of Sofer alone or with Japan 61256282 and further in view of Matzner or Kumpf, such that the final issue on appeal is whether the recited features of the aforementioned claims are rendered obvious in the sense of 35 U.S.C. §103 from the combined teachings of the aforementioned art.

(7) GROUPING OF CLAIMS

Appellants submit that the rejected claims do not stand or fall together and appellants present in the appropriate part or parts of the argument under the heading (8) ARGUMENT,

reasons as to why appellants consider the rejected claims to be separately patentable.

(8) ARGUMENT

I Rejections under 35 U.S.C. §112

(A) 35 U.S.C. §112, first paragraph

In the final Office Action dated February 26, 2001, the Examiner contends that there is no support in the original disclosure for the limitation of the definition of the fuel cycle in lines 12-17 of claim 24, lines 26-31 of claim 42, lines 9-14 of claim 56, lines 12-17 of claim 61, lines 26-31 of claim 62 and lines 9-14 of claim 63. More particularly, the Examiner states that:

> Note that the above referred to limitations in applicants claims incorrectly indicate that the "renewing" takes place <u>while</u> the fuel assembly is in the nuclear reactor.

Turning to claim 24, for example, the Examiner apparently considers the definition of "one fuel cycle" as not to be supported in the specification. Looking to claim 24, for example, the language is as follows:

> which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing at least one of the fuel assemblies in the nuclear reactor

The specification of the application at page 15, line 33 to page 16, line 3, provides:

> This operation method applies for one fuel cycle (operation period of a nuclear reactor from when the fuel in the reactor core is replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing the fuel, i.e., usually, one year).

Applicants note that the fuel is contained in a fuel assembly which fuel assembly and as is well known in the art and as described in the specification of this application, a plurality of fuel assemblies are loaded in a core arranged inside the reactor vessel of the nuclear reactor. Thus, fuel assemblies as described which are in the nuclear reactor are renewed when the nuclear reactor is stopped. The manner of renewal is obtained by changing the fuel of the fuel assembly and as well known in the art as represented by US Patent No. 4,285,769, cited at page 19 of the specification of the application, the fuel assemblies which are provided in the core of the reactor are represented by fuel assemblies being exposed for different fuel cycles as illustrated in Fig. 6A of this application. Applicants submit that the claims do not recite, as contended by the Examiner, that the "renewing" takes place <u>while</u> the fuel assembly is in the nuclear reactor, but rather recites that the nuclear reactor is stopped for renewing at least one of the fuel assemblies, which fuel assemblies have been operational in the nuclear reactor for the "one fuel cycle". Thus, the Examiner's position is

without merit and represents a strained interpretation of the claim language.

Applicants note that in the appeal of the parent application, as decided by the Board on February 8, 2000, a rejection of claims under 35 U.S.C. §112, first paragraph, was also not sustained with the Board stating:

> The written description requirement serves "to ensure that the inventor had possession, as of the filing date of the application relied on, of the specific subject matter later claimed by him; how the specification accomplishes this is not material." In re Wertheim, 541 F.2d 257, 262, 191 USPQ 90, 96 (CCPA 1976). In order to meet the written description requirement, the appellants do not have to utilize any particular form of disclosure to describe the subject matter claimed, but "the description must clearly allow persons of ordinary skill in the art to recognize that [he or she] invented what is claimed." In re Gosteli, 872 F.2d 1008, 1012, 10 USPQ2d 1614, 1618 (Fed. Cir. 1989). Put another way, "the applicant must . . . convey with reasonable clarity to those skilled in the art that, as of the filing date sought, he or she was in possession of the invention." Vas-Cath, Inc. v. Mahurkar, 935 F.2d 1555, 1563-64, 19 USPQ2d 1111, 1117 (Fed. Cir. 1991). Finally, "[p]ecisely how close the original description must come to comply with the description requirement of section 112 must be determined on a case-by-case basis." Eiselstein v. Frank, 52 F.3d 1035, 1039, 34 USPQ2d 1467, 1470 (Fed. Cir. 1995) (quoting Vas-Cath, 935 F.2d at 1561, 19 USPQ2d at 1116).
>
> With this as background, we have reviewed both (1) the specific rejection under 35 U.S.C. § 112, first paragraph, made by the examiner of the claims on appeal (answer, pp. 3-11) and (2) the appellants' argument against this rejection (brief, pp. 14-21, and reply brief, pp. 1-6). From this review, we are convinced that the claims under appeal meet the written description of the first paragraph of 35 U.S.C. §112, since the original disclosure establishes that the inventors had possession, as of the filing date of the application relied on,

> of the specific subject matter set forth in the claims under appeal for the reasons set forth by the appellants.
>
> For the reasons set forth above, the decision of the examiner to reject claims 4, 6, 7, 13, 14, 26, 28 to 31, 34, 35 and 41 to 52 under 35 U.S.C. §112, first paragraph, is reversed.

Appellants submit that it is evident that the Examiner's position is a strained interpretation of the claim language and full support for such language is found in the specification. Accordingly, appellants submit that the rejection under 35 U.S.C. §112, first paragraph, in a manner similar to the rejection found deficient by the Board in the related appeal should also be found deficient herein, and reversed.

Appellants note that independent claim 54 and its dependent claims 55 and 60, which are on appeal, do not stand rejected under 35 U.S.C. §112, first paragraph.

(B) The rejection under 35 U.S.C. §112, second paragraph

The rejection of claims 24, 26, 29, 40-43, 50, 52, 53, 56-59 and 61-63 under 35 U.S.C. §112, second paragraph, as being indefinite is based upon the same interpretation by the Examiner of the language in the claims, as utilized in the rejection under 35 U.S.C. §112, first paragraph, which is improper, as pointed out above. Hereagain, in the related appeal of the parent application, there was also a rejection under 35 U.S.C. §112, second paragraph, and the Board's decision in reversing such rejection is set forth below:

The second paragraph of 35 U.S.C. §112 requires claims to set out and circumscribe a particular area with a reasonable degree of precision and particularity. In re Johnson, 558 F.2d 1009, 1015, 194 USPQ 187, 193 (CCPA 1977). In making this determination, the definiteness of the language employed in the claims must be analyzed, not in a vacuum, but always in light of the teachings of the prior art and of the particular application disclosure as it would be interpreted by one possessing the ordinary level of skill in the pertinent art. Id.

The examiner's focus during examination of claims for compliance with the requirement for definiteness of 35 U.S.C. §112, second paragraph, is whether the claims meet the threshold requirements of clarity and precision, not whether more suitable language or modes of expression are available. Some latitude in the manner of expression and the aptness of terms is permitted even though the claim language is not as precise as the examiner might desire. If the scope of the invention sought to be patented can be determined from the language of the claims with a reasonable degree of certainty, a rejection of the claims under 35 U.S.C. §112, second paragraph, is inappropriate.

Furthermore, the appellants may use functional language, alternative expressions, negative limitations, or any style of expression or format of claim which makes clear the boundaries of the subject matter for which protection is sought. As noted by the Court in In re Swinehart, 439 F.2d 210, 160 USPQ 226 (CCPA 1971), a claim may not be rejected solely because of the type of language used to define the subject matter for which patent protection is sought.

With this as background, we have reviewed both (1) the specific rejection under 35 U.S.C. §112, second paragraph, made by the examiner of the claims on appeal (answer; pp. 11-13) and (2) the appellants' argument against this rejection (brief, pp. 21-22). From this review, we reach the conclusion that the claims under appeal are definite, as required by the second paragraph of 35 U.S.C. §112, since they define the metes and bounds of the claimed invention with a reasonable degree of precision and particularity for the reasons set forth by the appellants. In addition, we note that the mere breadth of features or elements recited in a claim does not in and of itself make a claim indefinite.[2]

For the reasons set forth above, the decision of the examiner to reject claims 4, 6, 7, 13, 14, 26, 28 to 31, 34, 35 and 41 to 52 under 35 U.S.C. §112, second paragraph, is reversed.

[2]Breadth of a claim is not to be equated with indefiniteness. See In re Miller, 441 F.2d 689, 169 USPQ 597 (CCPA 1971).

As pointed out above with respect to the rejection under 35 U.S.C. §112, first paragraph, the Examiner has provided a strained interpretation of the claim language and as recognized by the Board, if the scope of the invention sought to be patented from the language of the claims with a reasonable degree of certainty, a rejection of the claims under 35 U.S.C. §112, second paragraph, is inappropriate. Accordingly, the Board is urged to reverse the rejection by the Examiner of the claims under 35 U.S.C. §112, second paragraph.

Hereagain, claims 54, 55 and 60 which are on appeal have not been rejected in the above-noted manner.

II The rejections under 35 U.S.C. §103

In each of the rejections under 35 U.S.C. §103, a common thread appears in that the patent to Sofer (US 3,910,818) or Japan 61256282 has been utilized alone or in combination and with other cited references. Accordingly, the deficiencies of such references in relation to the claimed invention will initially be discussed below. Appellants submit that the Board's decision in the related application provides a

thorough discussion of obviousness rejections which corresponds somewhat to the type of rejections as presented in this appeal, and this portion of the Board's prior decision is set forth below.

> We will not sustain any of the rejections of claims 4, 6, 7, 13, 14, 26, 28 to 31, 34, 35 and 41 to 52 under 35 U.S.C. §103.
>
> In rejecting claims under 35 U.S.C. § 103, the examiner bears the initial burden of presenting a case of obviousness. See In re Rijckaert, 9 F.3d 1531, 1532, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993). A case of obviousness is established by presenting evidence that the reference teachings would appear to be sufficient for one of ordinary skill in the relevant art having the references before him to make the proposed combination or other modification. See In re Lintner, 458 F.2d 1013, 1016, 173 USPQ 560, 562 (CCPA 1972). Furthermore, the conclusion that the claimed subject matter is obvious must be supported by evidence, as shown by some objective teaching in the prior art or by knowledge generally available to one of ordinary skill in the art that would have led that individual to combine the relevant teachings of the references to arrive at the claimed invention. See In re Fine, 837 F.2d 1071, 1074, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988). Rejections based on §103 must rest on a factual basis with these facts being interpreted without hindsight reconstruction of the invention from the prior art. The examiner may not, because of doubt that the invention is patentable, resort to speculation, unfounded assumption or hindsight reconstruction to supply deficiencies in the factual basis for the rejection. See In re Warner, 379 F.2d 1011, 1017, 154 USPQ 173, 178 (CCPA 1967), cert. denied, 389 U.S. 1057 (1968).
>
> With this as background, we have reviewed all the rejections under 35 U.S.C. §103 made by the examiner of the claims on appeal (answer, pp. 14-28) and the appellants' argument against these rejections (brief, pp. 22-43, and reply brief, pp. 6-11). All of the §103 rejections are based on the examiner's determination that one difference between Patterson (the primary reference in all the rejections) and the claims under appeal is the limitation that all the coolant supplied to the coolant ascending path in the water rod is

introduced into the coolant descending path of the water rod. Patterson provides a plurality of intermediate exit holes 24 in his water rod 18. Accordingly, all of the coolant supplied to the coolant ascending path (shown by arrow 42 in Figure 4 of Patterson) in Patterson's water rod 18 is not introduced into the coolant descending path of his water rod 18 due to the fact that part of the water in the coolant ascending path exits the coolant ascending path via the plurality of intermediate exit holes 24 in the water rod 18 prior to reaching the descending path.

With regard to this difference, the examiner determined (answer, p. 16) that it would have been obvious to omit Patterson's plurality of intermediate exit holes 24 in his water rod 18 because of the known alternative water rod 32 taught in Figure 10 of Kumpf. We do not agree.

The Federal Circuit states that "[the] mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." In re Fritch, 972 F.2d 1260, 1266 n.14, 23 USPQ2d 1780, 1783-84 n.14 (Fed. Cir. 1992), citing In re Gordon, 773 F.2d 900, 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984). In our view, the only suggestion for modifying Patterson in the manner proposed by the examiner to meet the above-noted limitation stems from hindsight knowledge derived from the appellants' own disclosure. The use of such hindsight knowledge to support an obviousness rejection under 35 U.S.C. § 103 is, of course, impermissible. See, for example, W. L. Gore and Associates, Inc. v. Garlock, Inc., 721 F.2d 1540, 1553, 220 USPQ 303, 312-13 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984). Thus, we find ourselves in agreement with the appellants that the examiner has failed to establish a case of obviousness of the claimed subject matter for the reasons set forth by the appellants.

For the reasons set forth above, the decision of the examiner to reject claims 4, 6, 7, 13, 14, 26, 28 to 31, 34, 35 and 41 to 52 under 35 U.S.C. §103 is reversed.

(A) The rejection utilizing Japan 61256282 and Sofer

Turning to the rejection of claims 24, 50 and 61 based upon the combination of Japan 61256282 and Sofer, claim 24

defines a method for operating a nuclear reactor of the defined structure wherein, as shown in Figs. 3A-3C of the drawings of this application, a coolant surface formed between the coolant and a vapor in the at least one water rod is raised by increasing the flow rate of the coolant supplied to the core based on increasing a number of revolutions of the pump during one period from a beginning of one fuel cycle and before an end of the one fuel cycle, which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing at least one of the fuel assemblies. As shown in Fig. 17(d) of the drawings of this application, a fuel cycle is represented by the period indicated from 0 to 1, from 1 to 2, etc. As described in the specification, the flow rate is increased at some point in time and the one period of the fuel cycle during which the flow rate is increased is clearly illustrated. Claim 24 further recites the feature further increasing the flow rate of coolant supplied to the core based on increasing the number of revolutions of the pump during another period after the one period to an end of the one fuel cycle in a state in which the at least one water rod is completely filled with the coolant as represented by Fig. 3C of the drawings, and as described in the specification, the another period to the end of the fuel cycle is generally a period of 110% to 120% of the flow rate in the core. Claim 50

depends from claim 24 and recites the feature that the coolant is cooling water, whereas claim 61 corresponds to the features of claim 24, while defining the one fuel cycle in a manner similar to claim 24, with the modification of "when the nuclear reactor is stopped for renewing <u>a portion of the fuel assemblies</u> in the nuclear reactor".

In setting forth the rejection based upon 61256282, the Examiner indicates that the English language translation of Japan 61256282 clearly indicates that the fuel assembly remains in the reactor core for a whole or complete combination cycle (fuel cycle) without shuffling.

While the aforementioned document does disclose that the fuel assembly remains in the core for several cycles and that recent boiling water atomic reactors are designed, so that the fuel assembly is not moved by shuffling, such meaning is that the fuel assembly in the core stays at one position in the core during a residence time in the core from when the fuel assembly is loaded into the core to when the fuel assembly is taken out from the nuclear reactor. The residence time is several cycles. <u>The document does not disclose time of renewal of the fuel assembly.</u> However, Fig. 3 of such document is a characteristic diagram showing change of infinite multiplication factor <u>due to fuel cycles</u>. One skilled in the art of the nuclear reactor can understand that the renewal of the fuel assembly in the core is carried out at each end of <u>the first and the second cycles</u> by viewing Fig. 3,

because one skilled in the art of the nuclear reactor knows the above-mentioned renewal of the fuel assemblies disclosed in US 4,285,769. That is, Japan 61256282 teach the renewal of the fuel assembly at each end of the first, the second and third fuel cycles, wherein each of the fuel assembly loaded in the core at each end of the first and the second cycles resides at one position in the core during several fuel cycles.

In the present invention, the rise of the coolant surface formed in the water rod, and the complete filling of the water rod by the coolant are carried out in the water rod of all fuel assemblies loaded in the nuclear reactor in each fuel cycle.

In Japan 61256282, the rise of the coolant surface formed in the water rod, and the complete filling of the water rod by the coolant are not carried out in such fuel cycle by increasing the number of revolutions of the pump as recited in the independent claims of this application, irrespective of the whether the flow rate of the coolant supplied to the flow passage near the fuel rods (the flow passage formed between the fuel rods) is increased in the fuel assemblies which resided in the core during two fuel cycles after the deep cut formed in the upper portion of the water rod was meshed with the bar of the water rod penetration part in the fuel assemblies. Thus, the independent claims and dependent claims

patentably distinguish over Japan 61256282 in the sense of 35 U.S.C. §103 and should be considered allowable thereover.

As to the patent to Sofer, this patent discloses that flow rate of the coolant being supplied into the fuel assembly is increased toward the end of a fuel cycle, and that the increase of flow rate of the coolant is carried out in each fuel cycle. However, <u>Sofer only discloses the change of average void ratio</u> in the fuel assembly which corresponds to that described at page 19, lines 14-19 of the specification of this application. Thus, Sofer, like Japan 61256282, <u>fails to disclose or teach the rise of the coolant surface formed in the water rod</u>, and the <u>complete filling of the water rod by the coolant</u> in <u>each fuel cycle</u> by <u>increasing the number of revolutions</u> of the pump, as recited in the independent claims of this application. Accordingly, all claims patentably distinguish over the combination of Sofer and Japan 61256282 in the sense of 35 U.S.C. §103, and should be considered allowable thereover.

In addition to the deficiencies of the cited art as pointed out above, appellants submit that it is improper to combine the cited art because of inconsistent disclosures of the individual references. That is, the increase of flow rate of the coolant in Sofer is carried out <u>in each fuel cycle</u>, whereas the increase flow rate of the coolant in Japan 61256282 is carried out in the fuel assembly which resides in

the core for <u>two fuel cycles</u>. Thus, the Examiner has improperly combined the cited art. See <u>In re Fine, supra</u>.

(B) The addition of Japan 0220686 or Japan 0031090

As to the other cited art utilized in the rejection of the claims, appellants note that in Japan 0220686, the fuel assemblies loaded in the core include each of fuel assemblies of the first, second, third and fourth fuel cycles. Each of the fuel assemblies of the first, second, third and fourth fuel cycles have different residence times. Each of the fuel assemblies having different residence time is loaded into the core by shutting down the nuclear reactor at different times. It is apparent that the renewal of the fuel assembly in the core is carried out at each end of the first and the second cycles by viewing Figs. 4 and 5 of such document.

In Japan 0220686, the rise of the coolant surface formed in the water rod, and the filling of the coolant in the water rod are carried out at the same time as the <u>fuel assemblies which resides in the core during two fuel cycles</u>. The rise of the coolant surface formed in the water rod, and the filling of the coolant in the water rod are carried out <u>by removing the screw 11</u> (Fig. 3) or <u>cutting the lower end plug</u> (Fig. 6) from the water rod provided in the fuel assemblies <u>which resides in the core during two fuel cycles</u>. The screw 11 is removed from the water after the nuclear reactor is shut down at the end of second fuel cycle of the fuel assembly.

However, the fuel assemblies providing the water rod including the screw 11, that is, the fuel assemblies of the first and second fuel cycles shown in Fig. 4 have the water rod in which the coolant surface is formed between the coolant and the vapor. Thus, the core disclosed in Fig. 4 have the fuel assemblies (the fuel assemblies of the first and second fuel cycles) having the water rod in which the coolant surface is formed between the coolant and the vapor, and the fuel assemblies (the fuel assemblies of the third fuel cycle) having the water rod being completely filled with the coolant by removal of the screw without regard to increase of the number of revolutions of the pump.

In contradistinction, <u>in the present invention</u>, as recited in the independent claims, <u>the rise of the coolant surface formed in the water rod</u>, and the <u>complete filling of the water rod by the coolant are carried out in the water rod of all fuel assemblies</u> loaded in the nuclear reactor <u>in each fuel cycle</u>. Japan 0220686 does not disclose or teach that the rise of the coolant surface formed in the water rod, and the complete filling of the water rod by the coolant are carried out in all fuel assemblies loaded in the nuclear reactor <u>in each fuel cycle</u>.

Further, the teachings of this document is inconsistent with the teachings of Sofer and appellants submit that the cited art cannot be properly combined in the sense of 35 U.S.C. §103.

In Japan 0031090, the fuel assemblies loaded in the core include each of fuel assemblies of the first, second, third and fourth fuel cycles. Each of the fuel assemblies of the first, second, third and fourth fuel cycles have different residence time. Each fuel assembly having different residence time is loaded into the core by shutting down the nuclear reactor at different times. It is apparent that the renewal of the fuel assembly in the core is carried out at each end of the first and the second cycles by viewing Figs. 5 and 6 of the document.

In Japan 0031090, the rise of the coolant surface formed in the water rod, and the filling of the coolant in the water rod are carried out at the same time to the fuel assemblies which reside in the core <u>during two fuel cycles</u>. The rise of the coolant surface formed in the water rod, and the filling of the coolant in the water rod are carried out by <u>removing the screw 14</u> (Fig. 4) <u>from the water rod provided in the fuel assemblies which resided in the core during two fuel cycles</u>. The screw 14 is removed from the water after the nuclear reactor is shut down at the end of second fuel cycle of the fuel assembly. However, the fuel assemblies providing the water rod including the screw 14, that is, the fuel assemblies of the first and second fuel cycles shown in Fig. 5 have the water rod in which the coolant surface is formed between the coolant and the vapor. Thus, the core disclosed in Fig. 5 have the fuel assemblies (the fuel assemblies of the first and

second fuel cycles) having the water rod in which the coolant surface is formed between the coolant and the vapor, and the fuel assemblies (the fuel assemblies of the third fuel cycle) having the water rod being completely filled with the coolant by removal of the screw without regard to increasing the number of revolutions of the pump.

In contradistinction, <u>in the present invention, the rise of the coolant surface formed in the water rod</u>, and the complete filling of <u>the water rod by the coolant are carried out in all fuel assemblies loaded in the nuclear reactor in each fuel cycle</u> by the pump regulation. Japan 0031090, like the other cited art, does not disclose or teach that the rise of the coolant surface formed in the water rod, and the complete filling of the coolant in the water rod are carried out in all fuel assemblies loaded in the nuclear reactor <u>in each fuel cycle</u>. Further, the teachings of Japan 0031090 are inconsistent with the teachings of Sofer. Thus, appellants submit that Japan 0031090 cannot be properly combined with the other cited art in the sense of 35 U.S.C. §103.

(C-F) The addition of Matzner or Kumpf as well as rejection based upon additional claims

Matzner discloses a water rod which includes an entrance conduit from a high pressure lower plenum below the core plate and which extends through the fuel support, nose piece and lower tie plate. As described in Matzner, unlike the prior

art, communication of conduit 14 with higher pressure lower plenum 12 assures sufficient pressure to maintain stable flow of water only interior of water rod W and prevent flashing of water with water rod W to steam with resultant loss of the required moderator density. Fig. 2 of this patent illustrates a jet pump connected to conventional circulation pumps recirculating water moderator downward and concentrically of core 40 with the pump 50 forming below core separation plate P a high pressure plenum 12. Irrespective of this structure of Matzner, it is not seen how this structure when combined with the cited art discloses or teaches a method of operation of a nuclear reactor as recited in the claims of this application.

In addition to the features of independent claims 24 and 61, as described above, it is readily apparent that Matzner does not disclose the two period operation (one period and another period) before the end of the fuel cycle for increasing the number of revolutions of the pump and completely filling the water rod with coolant without vapor being present as recited in most of the independent and dependent claims. It is noted, however, that independent claim 54 and its dependent claims recite the feature of controlling the amounts of voids accumulated in the water rods by regulating a number of revolutions of a pump supplying coolant to the core as well as defining the structural features of the fuel assembly and that a plurality of the fuel assemblies are loaded in the reactor core. It is readily

apparent that Matzner taken alone or in combination with the other cited art fails to disclose or teach such features.

Claims 53 and 57, for example, recite that the step of raising the coolant surface includes increasing the flow rate of the coolant in the range of 0% to less than 110% of the flow rate during the one period and the step of further increasing the flow rate of the coolant includes increasing the flow rate above 110% of the flow rate during the another period. Such features have been ignored by the Examiner as merely using flow rate percentages as known in the art. It is apparent, however, that the cited art does not provide any disclosure or teaching of the recited features with the Examiner utilizing the principle of "obvious to try" which is not the standard of 35 U.S.C. §103 in setting forth such rejections. See In re Fine, supra.

With regard to Kumpf, this patent in Fig. 10 illustrates what may be considered a water rod in the form of a U-shaped tubular insert 32 through which coolant flows. However, irrespective of this structural arrangement, there is no disclosure or teaching of a method of operating a nuclear reactor wherein for each fuel cycle, a coolant surface formed between the coolant and vapor in the water rod is raised by increasing the flow rate of coolant based on increasing the number of revolutions of the pump during two different periods before an end of the fuel cycle, wherein in the another period after the one period to an end of the one fuel cycle, there is

provided a state in which the at least one water rod is completely filled with the coolant. Also, there is no disclosure or teaching in Kumpf regarding the different flow rate percentages to achieve the recited features nor the other features as recited in the independent and dependent claims of this application. Thus, Kumpf, like Matzner, does not overcome the deficiencies of the other cited art and cannot be properly combined with the other cited art in the sense of 35 U.S.C. §103.

(9) CONCLUSION

For the foregoing reasons, appellants request that the Board of Appeals find that the rejections of the claims under 35 U.S.C. §112, first and second paragraphs, and the rejections of the claims under 35 U.S.C. §103, as set forth by the Examiner, are erroneous. Thus, appellants respectfully urge the Board of Appeals to reverse all rejections as set forth by the Examiner in the final Office Action.

The Appeal Brief fee in the amount of $320.00 is submitted herewith.

To the extent necessary, appellant's petition for an extension of time under 37 CFR 1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account

No. 01-2135 (501.25507CX5) and please credit any excess fees to such deposit account.

Respectfully submitted,

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APPENDIX

24. A method for operating a nuclear reactor having a reactor vessel, a plurality of fuel assemblies loaded in a core arranged inside the reactor vessel, wherein each of said plurality of fuel assemblies includes a plurality of fuel rods and at least one water rod therein, and a pump which regulates a flow rate of coolant supplied to the core, the method comprising the steps of:

raising a coolant surface formed between the coolant and a vapor in the at least one water rod by increasing the flow rate of the coolant supplied to the core based on increasing a number of revolutions of the pump during one period from a beginning of one fuel cycle, which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing at least one of the fuel assemblies in the nuclear reactor, and before an end of the one fuel cycle; and

further increasing the flow rate of coolant supplied to the core based on increasing the number of revolutions of the pump during another period after the one period to an end of the one fuel cycle in a state in which the at least one water rod is completely filled with the coolant.

26. A method according to claim 24, wherein each of said plurality of fuel assemblies include an upper tie plate, a lower tie plate, the plurality of fuel rods having upper end portions held by the upper tie plate and lower end portions held by a fuel rod holding portion of the lower tie plate, the fuel rods being each filled with a plurality of fuel pellets, and the at least one water rod being arranged among the fuel rods, a resistance member provided at a lower end portion of the fuel assembly, a coolant ascending path in which the at least one water rod has a coolant inlet port open in a region lower than the resistance member, and a coolant descending path which is communicated with the coolant ascending path and which has a coolant delivery port that is open in a region higher than the resistance member, in order to guide the coolant downwardly in an opposite direction to a direction in which the coolant flows in the coolant ascending path.

29. A method according to claim 26, wherein the resistance member is the fuel rod holding portion of the lower tie plate.

40. A method according to claim 26, wherein the coolant ascending path in the at least one water rod is located so as to extend beyond an upper end of a fuel pellet-filled region of the fuel rods of the at least one fuel assembly.

41. A method according to claim 26, wherein an upper end of the coolant ascending path in the at least one water rod is

located at a position lower than an upper end of a fuel pellet-filled region of the fuel rods of the at least one fuel assembly.

42. A method according to claim 40, the coolant delivery port of the at least one water rod is located at a position near a lower end of the fuel pellet-filled region.

43. A method according to claim 26, wherein the coolant descending path of the at least one water rod is located so as to surround the coolant ascending path of the at least one water rod.

50. A method according to claim 24, wherein the coolant is cooling water.

52. A method for operating a nuclear reactor having a reactor vessel and at least one fuel assembly loaded in a core arranged inside the reactor vessel, the at least one fuel assembly having an upper tie plate, a lower tie plate, a plurality of fuel rods having upper end portions held by the upper tie plate and lower end portions held by a fuel rod holding portion of the lower tie plate, at least one water rod arranged among the fuel rods, and a resistance member at a lower end portion of the at least one fuel assembly, the plurality of fuel rods having a plurality of fuel pellets therein, and the at least one water rod having a coolant ascending path including a coolant inlet port which is open in

a region lower than the resistance member, and a coolant descending path which is communicated with the coolant ascending path, the coolant descending path having a coolant delivery port open in a region higher than the resistance member, the coolant being guided downwardly in the coolant descending path in an opposite direction of the coolant flow in the coolant ascending path, the method comprising the step of regulating a flow rate of the coolant supplied to the core by a pump including the steps of:

raising a coolant surface formed between the coolant and a vapor in the at least one water rod by increasing the flow rate of the coolant supplied to the core based on increasing a number of revolutions of the pump during one period from a beginning of one fuel cycle, which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing at least one of the fuel assemblies in the nuclear reactor, and before an end of the one fuel cycle; and

further increasing the flow rate of the coolant supplied to the core based on increasing the number of revolutions of the pump during another period after the one period to an end of the one fuel cycle in a state in which the at least one water rod is completely filled with the coolant and no vapor is present in the at the another period.

53. A method according to claim 52, wherein the step of raising the coolant surface includes increasing the flow rate of the coolant in the range of 0% to less than 110% of the flow rate during the one period and the step of further increasing the flow rate of the coolant includes increasing the flow rate above 110% of the flow rate during the another period.

54. A method for operating a nuclear reactor having a reactor vessel and at least one fuel assembly loaded in a core arranged inside the reactor vessel, the at least one fuel assembly having an upper tie plate, a lower tie plate, a plurality of fuel rods having upper end portions held by the upper tie plate and lower end portions held by a fuel rod holding portion of the lower tie plate, a plurality of water rods arranged among the fuel rods, and a resistance member at a lower end portion of the at least one fuel assembly, the plurality of fuel rods having a plurality of fuel pellets therein, and each of the water rods having a coolant ascending path including a coolant inlet port which is open in a region lower than the resistance member, and a coolant descending path which is communicated with the coolant ascending path, the coolant descending path having a coolant delivery port open in a region higher than the resistance member, the coolant being guided downwardly in the coolant descending path in an opposite direction of the coolant flow in the coolant ascending path, the method comprising the steps of:

loading a plurality of the fuel assemblies in the reactor core; and

controlling the amounts of voids accumulated in the water rods by regulating a number of revolutions of a pump supplying coolant to the core.

56. A method according to 54, wherein the step of controlling the amount of voids includes the step of regulating a flow rate of coolant supplied to the core including the steps of:

raising a coolant surface formed between the coolant and a vapor in the water rods by increasing the flow rate of the coolant supplied to the core based on increasing the number of revolutions of the pump during one period from a beginning of one fuel cycle, which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing at least one of the fuel assemblies in the nuclear reactor, and before an end of the one fuel cycle; and

further increasing the flow rate of the coolant supplied to the core based on increasing the number of revolutions of the pump during the another period in a state in which the water rods are completely filled with the coolant and no vapor is present in the water rods at the another period.

57. A method according to claim 56, wherein the step of raising the coolant surface includes increasing the flow rate

of the coolant in the range of 0% to less than 110% of the flow rate during the one period and the step of further increasing the flow rate of the coolant includes increasing the flow rate above 110% of the flow rate during the another period.

58. A method according to claim 24, wherein the at least one water rod includes a coolant ascending path having a coolant inlet port and a coolant descending path connected with the coolant ascending path at a top portion thereof so that all of the coolant supplied into the coolant ascending path is introduced into the coolant descending path in a downward direction opposite to the direction of the flow of the coolant in the coolant ascending path, the coolant descending path having a coolant delivery port.

59. A method according to claim 52, wherein the coolant descending path is communicated with the coolant descending path at a top portion of the coolant ascending path so that all of the coolant supplied into the coolant ascending path is introduced into the coolant descending path in the downward direction opposite to the direction of the flow of the coolant in the coolant descending path.

60. A method according to claim 54, wherein the coolant descending path is communicated with the coolant descending path at a top portion of the coolant ascending path so that all of the coolant supplied into the coolant ascending path is

62. A method for operating a nuclear reactor having a reactor vessel and at least one fuel assembly loaded in a core arranged inside the reactor vessel, the at least one fuel assembly having an upper tie plate, a lower tie plate, a plurality of fuel rods having upper end portions held by the upper tie plate and lower end portions held by a fuel rod holding portion of the lower tie plate, at least one water rod arranged among the fuel rods, and a resistance member at a lower end portion of the at least one fuel assembly, the plurality of fuel rods having a plurality of fuel pellets therein, and the at least one water rod having a coolant ascending path including a coolant inlet port which is open in a region lower than the resistance member, and a coolant descending path which is communicated with the coolant ascending path, the coolant descending path having a coolant delivery port open in a region higher than the resistance member, the coolant being guided downwardly in the coolant descending path in an opposite direction of the coolant flow in the coolant ascending path, the method comprising the step of regulating a flow rate of the coolant supplied to the core by a pump including the steps of:

raising a coolant surface formed between the coolant and a vapor in the at least one water rod by increasing the flow rate of the coolant supplied to the core based on increasing a number of revolutions of the pump during one period from a beginning of one fuel cycle, which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation

of the nuclear reactor is started to when the nuclear reactor is stopped for renewing a portion of the fuel assemblies in the nuclear reactor, and before an end of the one fuel cycle; and

further increasing the flow rate of the coolant supplied to the core based on increasing the number of revolutions of the pump during another period after the one period to an end of the one fuel cycle in a state in which the at least one water rod is completely filled with the coolant and no vapor is present in the at the another period.

63. A method according to 62, wherein the step of controlling the amount of voids includes the step of regulating a flow rate of coolant supplied to the core including the steps of:

raising a coolant surface formed between the coolant and a vapor in the water rods by increasing the flow rate of the coolant supplied to the core based on increasing the number of revolutions of the pump during one period from a beginning of one fuel cycle, which one fuel cycle is an operation period of the nuclear reactor from when fuel assemblies in the nuclear reactor are replaced and operation of the nuclear reactor is started to when the nuclear reactor is stopped for renewing a portion of the fuel assemblies in the nuclear reactor, and before an end of the one fuel cycle; and

further increasing the flow rate of the coolant supplied to the core based on increasing the number of revolutions of the pump during the another period in a state in which the

water rods are completely filled with the coolant and no vapor is present in the water rods at the another period.

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